

HAPTIC MOUSE INTERFACE SYSTEM FOR PROVIDING  
FORCE AND TACTILE FEEDBACKS TO USER'S FINGERS AND ARM

Priority Claim

5        This application claims priority from Korean Patent  
Application Nos. 10-2003-0002941 and 10-2003-0073554 filed 16  
January 2003 and 21 October 2003, respectively, which is  
herein incorporated by references.

10    Field of the Invention

      The present invention relates to a haptic mouse interface  
system which provides a user with force and tactile feedbacks  
to allow the user to feel the mechanical properties and tactile  
sensations of a virtual object, and more particularly, to a  
15 haptic mouse interface system which provides a user with force  
and tactile feedbacks to allow a user to feel as if he/she is  
in contact with the virtual object.

Description of the Prior Art

20        In general, computer users experience virtual objects by  
manipulating games, simulations and the like in virtual  
realities provided by computers. Such an interface device,  
which allows a user to interact with a computer, includes a  
mouse, a joystick, a steering wheel, a tablet and so on. The  
25 interface device generates control signals or commands to a

virtual object, or allows a user to physically feel a virtual object. Accordingly, the interface device requires an additional unit, which is familiar to a user, for providing force feedback to the user, so as to enable the user to feel  
5 the physical properties of a virtual object.

A conventional interface device, which has such a unit for generating force feedback, is disclosed in U.S. Pat. No. 6,191,774. Fig. 1 is a perspective view of the mouse interface disclosed in U.S. Pat. No. 6,191,774.

10 As shown in Fig. 1, the mouse interface 14 includes a mouse 12, a mechanical linkage 40 and a transducer system 41.

The linkage 40 is a 5-member linkage including a ground member 42, a first base member 44 coupled to the ground member 42, a second base member 48 coupled to the ground member 42, a  
15 link member 46 coupled to the first base member 44, and an object member 50 coupled to the link member 46, the second base member 48 and the mouse 12. The members of the linkage 40 are rotatably coupled to one another through the use of rotatable pivots or bearing assemblies having one or more bearings.

20 The transducer system 41 includes sensors 62 and actuators 64. The sensors 62 collectively sense the movement of the mouse 12 in the provided degrees of freedom and send appropriate signals to an electronic portion of the interface 14. The actuators 64 transmit forces to the mouse 12 in a  
25 space, i.e., in two (or more) degrees of freedom of the user

object. The actuators 64 are electromagnetic voice coil actuators, which provide a force through the interaction of a current in a magnetic field.

By the above-described configuration, a user using the  
5 interface can sense motions of a virtual object in an application program driven by a computer through mechanical vibration of the mouse.

However, the interface can allow a user to feel only tactile sensations, such as a motion and a vibration of a  
10 virtual object, but cannot allow the user to perceive the various mechanical properties of the virtual object, such as the size, weight, shape and hardness of the virtual object. In addition, the above interface cannot offer the motions of a virtual object separately to user's fingers and arm.

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#### SUMMARY OF THE INVENTION

Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide a haptic mouse  
20 interface system having a first force feedback unit and a second force feedback unit, which provides the user's fingers and arm with force and tactile feedbacks to allow the user to perceive the various mechanical properties and tactile sensations of the virtual object, such as the size, weight,  
25 shape and hardness of the virtual object.

Another object of the present invention is to provide a haptic mouse interface system for providing the user's fingers and arm with force and tactile feedbacks with less tiredness.

In order to accomplish the above object, the present invention provides a haptic mouse interface system which provides force and tactile feedbacks to a user's hand and fingers to allow the user to feel a virtual object displayed on a computer screen, the haptic mouse interface system including: a mouse; a first force feedback unit including: first and second encoders to receive signals respectively corresponding to a mechanical property in a first direction of the virtual object; first and second motors driven by the first and second encoders and having shafts, respectively; and a linkage, which is operationally connected at a ground joint thereof to shafts of the first and second motors and connected at another joint to the mouse to provide a first force feedback to the user's hand and arm; a second force feedback unit provided in the mouse, including: a third encoder to receive a signal corresponding to the mechanical property in second and third directions perpendicular to the first direction of the virtual object; a third motor driven by the third encoder and having a shaft; and a pair of finger pads provided at both sides of the mouse and linearly moved by the third motor to provide a second force feedback to the user's fingers; and a tactile feedback unit provided in the mouse, including: at least one actuator

attached to the mouse; and a plurality of pins coupled to the actuator to come into contact with the user's fingers, wherein the at least one actuator receives signals corresponding to surface properties of the virtual object, and drives the plurality of pins according to the received signals, thereby  
5 providing pressure or vibration exhibiting the surface properties of the virtual object to the user's fingers.

The second force feedback unit may further include a pair of cables, which are connected to the pair of finger pads,  
10 respectively, and wound around the shaft of the third motor, so as to transform a rotational movement of the third motor into linear movements of the pair of finger pads.

Each of the pair of finger pads may includes a pin head to be in contact with the user's fingers and having a slit, and a  
15 pin rod extended from the pin head and having a longitudinal guide groove formed on an outer surface thereof. Each of the pair of cables surrounds the corresponding finger pad through the guide groove formed on the pin rod and the slit of the pin head.

20 Each of the finger pads may include a bolt tightened into a threaded hole of the pin head, and a tension bar having a hole through which the bolt passes and moves together with the bolt. Thus, the tension bar is moved close to and away from the pin head when the bolt is tightened and loosened.

25 The linkage may be comprised of four bars hingedly

connected at ends portions thereof, in which two bars connected to a first hinge point corresponding to the first joint of the linkage are operationally connected to the shafts of the first and second motors to be moved, respectively, and the other two  
5 bars are connected to a second hinge point corresponding to the second joint of the linkage which is positioned diagonally opposite to the first hinge point and connected to the mouse.

The haptic mouse interface system may further include a mouse plate fixed to the first force feedback unit and  
10 positioned between the linkage and the mouse so as to allow a user's wrist to be placed thereon.

The mouse plate may be formed with a communicating hole through which the second hinge point of the linkage is connected to the mouse. The communicating hole is formed into  
15 a sector shape having an area larger than an operating range of the second hinge point fixed to the mouse.

The tactile feedback unit may include a plurality of plate-shaped actuators which can be bent upon its activation, and a holding base attached to the mouse and having a plurality  
20 of steps. The plurality of plate-shaped actuators is sequentially attached to the corresponding steps of the holding base, respectively, and is provided at its free end with the plurality of pins.

The actuators of the tactile feedback unit may be bimorph  
25 type of bendable piezoelectric actuator.

The pins coupled to the actuator may be arranged such that free ends of the pins are positioned at the same plane.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5       The above and other objects, features and advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view schematically showing a  
10 conventional mouse interface which provides a user with force feedback according to a shape of a virtual object;

FIG. 2 is a schematic view of a haptic mouse interface system according to an embodiment of the present invention, which is constructed to provide the user's fingers and arm with  
15 force and tactile feedbacks so as to allow the user to perceive physical properties of a virtual object;

FIG. 3 is a perspective view of the haptic mouse interface system shown in FIG. 2;

FIG. 4 is an exploded perspective view showing the first  
20 force feedback unit and the second force feedback unit of the haptic mouse interface system shown in FIG. 3;

FIG. 5 is a perspective view showing a linkage of the first force feedback unit to drive the second force feedback unit, in which a mouse plate is removed from the haptic mouse  
25 interface system;

FIG. 6 is a partial perspective view of the first force feedback unit showing a way of coupling between motor shafts and the linkage shown in FIG. 5;

FIG. 7 is a perspective view showing an internal structure  
5 of the second force feedback unit of the haptic mouse interface system shown in FIG. 4;

FIG. 8 is a front view schematically showing an operational relationship between finger pads and a motor shaft provided in the second force feedback unit shown in FIG. 7;

10 FIG. 9 is a perspective view showing one of the finger pads shown in FIG. 8;

FIG. 10 is a perspective view showing a body on which the finger pads and the motor shaft of the second force feedback unit shown in FIG. 7 are mounted;

15 FIG. 11 is a perspective view showing a modification of the finger pads shown in FIG. 9;

FIG. 12 is a perspective view of a haptic mouse interface system including a tactile feedback unit, according to another embodiment of the present invention;

20 FIG. 13 is a perspective view of the tactile feedback unit;

FIG. 14 is a plan view of the tactile feedback unit of FIG. 13; and

FIG. 15 is a perspective view showing only one actuator of  
25 the tactile feedback unit, which actuates pins thereof to



provide tactile sensation to the user's fingers.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention will be described in further detail  
5 by way of example with reference to the accompanying drawings.

FIG. 2 is a schematic view of a haptic mouse interface  
system according to an embodiment of the present invention,  
which is constructed to provide the user's fingers and arm with  
force feedback so as to allow the user to perceive the  
10 mechanical properties of a virtual object, and FIG. 3 is a  
perspective view of the haptic mouse interface system shown in  
FIG. 2.

As shown in FIGS. 2 and 3, the haptic mouse interface  
system 100 of the present invention receives signals  
15 corresponding to mechanical properties in a first direction 114  
of a virtual object 111 displayed on a display screen 110 via  
first and second encoders 121 and 122 of a first force feedback  
unit 120. The first and second encoders 121 and 122 drive  
first and second motors 123 and 124 to rotate shafts thereof,  
20 thus providing force feedback to a user's hand grasping a  
second force feedback unit 130. Further, the haptic mouse  
interface system 100 receives signals corresponding to the  
mechanical properties in the second and third directions 115  
and 116 perpendicular to the first direction 114 of a virtual  
25 object 111 via a third encoder 132 (FIG. 4) of the first force

feedback unit 120, and then drives a third motor 133 (FIG. 4) connected to the third encoder 132. The third motor 133 moves left and right finger pads 140 and 141 provided at both sides of the second force feedback unit 130, thus providing force  
5 feedback to the user's thumb and fourth finger.

FIG. 4 is an exploded perspective view showing the first force feedback unit and the second force feedback unit of the haptic mouse interface system shown in FIG. 3, FIG. 5 is a perspective view showing a linkage of the first force feedback  
10 unit to drive the second force feedback unit, in which a mouse plate is removed from the haptic mouse interface system, and FIG. 6 is a partial perspective view of the first force feedback unit showing a way of coupling between motor shafts and the linkage.

15 As shown in FIGS. 2 to 6, the first force feedback unit 120 of the haptic mouse interface system 100 includes a cabinet 125, which has a pair of plates spaced apart from each other. On the upper plate of the cabinet 125, the first and second motors 123 and 124 are mounted. The first and second encoders  
20 121 and 122 are coupled to upper ends of the first and second motors 123 and 124, respectively.

Each of the encoders includes a plurality of input terminals and a plurality of output terminals. When a signal is applied to one of the input terminals of the encoder, an  
25 output signal is generated by combinations of output terminals

corresponding to the one of the input terminals. The first and second encoders 121 and 122 receive signals corresponding to the mechanical properties in connection with the first direction 114 of the virtual object 111 displayed on the display screen 110, and drives the first and second motors 123 and 124 to rotate the shafts thereof at respective rotational speeds according to the received signals.

The first and second motors 123 and 124 are connected at end portions thereof to a four-member linkage 127 positioned inside the cabinet 125. A first hinge pin 128a of the linkage 127 is fixed to the upper plate of the cabinet 125. First and second sector-shaped link connectors 126a and 126b are rotatably fitted on the first hinge pin 128a, respectively, such that the first and second link connectors 126a and 126b are rotated by respective corresponding cables, wherein each of the cables is wound around the first and second motor shafts and coupled at its both ends to both side ends of the link connector, respectively. Since the first and second link connectors 126a and 126b are integrally joined to bars of the linkage 127, respectively, the linkage 127 is driven by rotation of the first and second motors 123 and 124. A second hinge pin 128b, which is positioned diagonally opposite to the first hinge pin 128a of the linkage 127, is fixed to the second force feedback unit 130.

The mouse plate 129 is attached to the upper plate of the

cabinet 125 to be disposed between the second force feedback unit 130 and the linkage 127, so that a wrist of a user's hand grasping the second force feedback unit 130 can be placed on the mouse plate 129. The mouse plate 129 is formed with a communicating hole through which the second hinge pin 128b and the second force feedback unit 130 are coupled to each other. Since the second force feedback unit 130 moves two-dimensionally on the mouse plate 129 with reference to the first hinge pin 128a by the operation of the linkage 127, the communicating hole of the mouse plate 129 is preferably formed into a sector shape, which is larger than an operating range of the second hinge pin 128b fixed to the second force feedback unit 130.

FIG. 7 is a perspective view showing an internal structure of the second force feedback unit of the haptic mouse interface system shown in FIG. 4, FIG. 8 is a front view schematically showing a relationship between finger pads and a motor shaft provided in the second force feedback unit shown in FIG. 7, FIG. 9 is a perspective view showing one of the finger pads shown in FIG. 8, and FIG. 10 is a perspective view showing a body on which the finger pads and the motor shaft of the second force feedback unit shown in FIG. 7 are mounted.

As shown in FIGS. 2, 4, 7 and 10, the second force feedback unit 130 includes a hexahedral case 131 containing the third encoder 132. The second hinge pin 128b is fixed to a

bottom surface of the case 131. The third encoder 132 is coupled to the third motor 133, so as to drive the third motor 133 according to the mechanical information of a virtual object in the second and third directions 115 and 116 which is transmitted to the third encoder 132. The third motor 133 is coupled to a body 134, and the motor shaft 135 of the third motor 133 protrudes through a first fitting hole 136 formed in the body 134.

The body 134 is cut away at its center portion, such that the body 134 is of U-shaped and has protrusions 138 at both sides. Each of the protrusions 138 of the body 134 is laterally formed at each side portion of the body 134, and has second fitting holes 137, respectively, into which a pair of finger pads 140 are fitted. The center portion of the body 134 has a first fitting hole 136 into which the motor shaft 135 is fitted.

Each of the finger pads 140, which is inserted into one of the second fitting holes 137 of the body 134, includes a disc-shaped pin head 143 having a contact surface, with which the user's fingers contact, and a pin rod 144 extended from an inner surface of the pin head 143. The pin rod 144 is longitudinally formed with a guide groove 145 in which a cable 146 is disposed. The pin head 143 is formed with a slit 147, so that the cable 146 received in the guide groove 145 passes through the slit 147.

The pair of finger pads 140 and 141 are inserted into the second fitting holes 137 to be positioned on and under the motor shaft 135 inserted in the first fitting hole 136, respectively. The pair of finger pads 140 and 141 are linearly  
5 moved toward and away from each other by the rotation of the motor shaft 135. To this end, each of the cables 146 is wound around the motor shaft 135, and tightly fixed to the corresponding finger pad 140 or 141 at its both ends. In order to reduce is friction between the pin rods 144 and the second  
10 fitting holes 137 during the linear movement of the pin rods 144, the finger pads 140 and 141 are provided with ball bushings 142a and 142b fitted thereon.

FIG. 11 is a perspective view showing a modification of the finger pad shown in FIG. 9. The finger pad 140 shown in  
15 FIG. 11 is provided on an outer surface of the pin head 143 with a pair of bolts 148 and a tension bar 149, in order to control a tension force of the cable 146. More specifically, the cables 146 must be maintained in a tightened state so as to reliably transform a rotational movement of the motor shaft 135  
20 into a linear movement of the finger pads 140 and 141. To this end, the tension bar 149 is surrounded with the cable 146, and the tension bar 149 is movable close to and away from the pin head 143 by tightening and loosening either or both of the pair of bolts 148. That is, when either or both of the bolts 148  
25 are rotated in a releasing direction, the tension bar 149 is

moved away from the pin head 143, thus tightening the cable 146 surrounding the finger pads 140 or 141.

A haptic mouse interface system according to another embodiment of the present invention, which includes a tactile  
5 feedback unit to provide tactile sensations of a virtual object to user's fingers, will now be described.

FIG. 12 is a perspective view of a haptic mouse interface system including a tactile feedback unit, according to another embodiment of the present invention, which is intended to  
10 provide tactile sensations to user's fingers, FIG. 13 is a perspective view of the tactile feedback unit, FIG. 14 is a plan view of the tactile feedback unit of FIG. 13, and FIG. 15 is a perspective view showing only one actuator of the tactile feedback unit, which actuates pins thereof to provide tactile  
15 sensation to the user's fingers.

As shown in FIGS. 13 and 14, the tactile feedback unit 200 includes a pin array having plurality sets of pins 210, which come into contact with user's fingers, and a plurality of actuators 220 to drive the pins 210 of the pin array. Signals  
20 according to a shape and surface properties of a virtual object are transmitted to each of the actuators 220 of the tactile feedback unit 200. The tactile feedback unit 200 changes vibration frequencies and vibration amplitudes of the pins 210 according to the signals transmitted to the actuators 220, so  
25 as to allow the user to feel tactile sensations of the virtual

object. Further, the tactile feedback unit 200 can change displacements and pushing forces of the pins 210 to change the pressure acting on user's fingers.

Each of the actuators 220 of the tactile feedback unit 200  
5 is a bimorph type of bendable piezoelectric actuator, which drives the pins 210 fixed to a free end thereof, and controls a vibration frequency, vibration amplitude and pushing force of the pins 210. Each of the actuators 220 is provided at one end thereof with a plurality of pins 210, and is fixed at the other  
10 end thereof to a step portion of a holding base 230. The holding base 230 is attached to the second force feedback unit 130 via a support member 230.

Operations of the haptic mouse interface system 100 according to the present invention will now be described.

15 To allow a user to perceive the mechanical properties of the virtual object 112 displayed on the display screen 110, the haptic mouse interface system 100 provide a user's palm with force feedback in a first direction 114 of the virtual object 111, and the user's fingers grasping the second force feedback  
20 unit 130 with force feedback in second and third directions 115 and 116 perpendicular to the first direction 114 of the virtual object 111.

Signals corresponding to the mechanical properties in the first direction of the virtual object 111 are transmitted to  
25 the first and second encoders 121 and 122, and thus the first



and second encoders 121 and 122 drive the first and second motors 123 and 124 to rotate the shafts thereof. As a result, the first and second motors 123 and 124 drive the linkage 127 connected to the second force feedback unit 130, thus moving  
5 the second force feedback unit 130 in a direction corresponding to the first direction 114. Therefore, the second force feedback unit 130 transmits force feedback to a palm and an arm of a user's hand grasping the second force feedback unit 130, thereby allowing the user 112 to perceive the mechanical  
10 properties, such as a tactile sensation, weight and size of the virtual object 111.

Meanwhile, signals corresponding to the mechanical properties in the second and third directions of the virtual object 111 are transmitted to the third encoder 132, and thus  
15 the third encoder 132 drives the third motor 133 in the second force feedback unit 130 to rotate the shaft thereof. At this time, since the motor shaft 135 is operationally connected to the pair of finger pads 140 and 141 provided at both sides of the second force feedback unit 130, via the cables 146 wound on  
20 the motor shaft 135 and fixed to finger pads 140 and 141, the finger pads 140 and 141 are linearly moved in a lateral direction of the second force feedback unit 130 by rotation of the third motor 133. Since the user's thumb and second finger are in contact with the pin heads 143 of the finger pads 140  
25 and 141, the user can perceive mechanical properties such as a

surface roughness of the virtual object 111, a force for gripping the virtual object 111 and so on.

Further, the tactile feedback unit 200, which is coupled to the second force feedback unit, drives the pins 210 of the pin array fixed to the plurality of actuators 220 according to signals corresponding to a shape and surface properties of a virtual object, thereby transmitting pressure, vibration and tactile sensation to user's fingers.

As described above, the present invention provides a haptic mouse interface system, which provides the user's fingers and arm with force feedback to allow the user to perceive the various mechanical properties of the virtual object, such as the size, weight, shape and hardness of the virtual object.

In addition, the haptic mouse interface system according to the present invention enables a user to perceive a fitted state and a dimensional tolerance of assembling components by a tactile sensation in design tasks by CAD, and enables a user to directly feel qualities of goods displayed in shopping malls on the Internet as well as virtual objects displayed during computer games.

Although a haptic mouse interface system according to a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and

substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.